UPC 054

DRAFT
S. Ecklund
1/11/79

VACUUM REQUIREMENTS FOR $\bar{p}p$ COLLIDING BEAMS

It is required for $\bar{p}p$ colliding beams that the average pressure in the Doubler Ring be low enough so that both the beam loss due to nuclear collisions and the transverse growth due to multiple scattering not limit the luminosity. For $\bar{p}$ collection times of the order of 3 hours, we require lifetimes greater than that in order to have useful average luminosities. In this note we will require 10 hour lifetimes.

The beam loss due to nuclear scattering can be written as (see G. Guignard, CERN 77-10):

$$\frac{1}{I}\frac{dI}{dt} = (750 \text{ torr}^{-1}\text{sec}^{-1})\, P_{NS}$$

where P_{NS} is the equivalent nitrogen nuclear scattering pressure.

$$\frac{1}{I}\frac{dI}{dt} < (10 \text{ hr})^{-1} \text{ gives}$$

$$P_{NS} < 3.7 \times 10^{-8} \text{ torr}$$

The transverse growth is given by

$$\frac{d\sigma^2}{dt} = 0.1112\, \frac{\bar{\beta}\beta}{p^2}\, P_{MS}$$

where $\bar{\beta}$ = average β in the ring = 50 m

β = β function where beam size σ is measured

p = momentum in GeV/c

P_{MS} = equivalent nitrogen multiple scattering pressure

If we allow the beam size to increase by a factor $(1+\alpha)$ in a time Δt and take an initial transverse emittance (horizontal or vertical) equal to observed values in the main ring we have

$$\varepsilon = \frac{20\ \pi \times 10^{-6}}{p}\ \text{m - GeV/c}$$

$$\sigma^2 = \frac{\varepsilon\beta}{6\pi} = \frac{20\pi}{6\pi}\ \frac{\beta}{p} \times 10^{-6}\ \text{m-GeV/c}$$

$$\Delta\sigma^2 = (.1112)\ \frac{\overline{\beta}\beta}{p^2}\ P_{MS}(\Delta t) < \alpha\ \frac{\varepsilon\beta}{6\pi}$$

$$P_{MS} < \frac{\alpha}{\Delta t}\ \frac{\varepsilon}{(6\pi\overline{\beta})}\ \frac{p^2}{(.1112)}$$

$$P_{MS} < \frac{\alpha}{\Delta t}\ \frac{20\ \pi \times 10^{-6}}{6\pi(50\text{m})(.1112)}\ p$$

$$P_{MS} < \frac{\alpha}{\Delta t}\ 6.0 \times 10^{-7}\ p\ \ \text{torr-sec/GeV/c}$$

for a factor of 2 growth in 10 hours

$$P_{MS} < 1.7 \times 10^{-11}\ p\ \ \text{torr/GeV/c}$$

at 100 GeV/c this gives

$$P_{MS} < 1.7 \times 10^{-9}\ \text{torr}$$

I have assumed that one would run colliding beams as low as 100 GeV/c; at 1 TeV the vacuum requirement is eased by a factor of 10.

The above pressure requirements are for the average pressure in the ring assuming the gas to be nitrogen. Since only 7% of the ring will be warm bore and the cold bore should have an excellent vacuum, the requirements for warm bore vacuum can be raised by a factor of 14. Thus far the warm bore equivalent nitrogen vacuum

$$P_{MS} < 2.4 \times 10^{-8}\ \text{torr}$$

If the gas composition contains appreciable amounts of H_2 as does the main ring (see 77 Summer Study p. 115, 221), the actual pressure will be about 1/2 the equivalent nitrogen pressure. Therefore a reasonable requirement for warm bore vacuum is 1.0×10^{-8} torr.

SE/nep